

OPERATORS HANDBOOK

This Operators Handbook supplements the complete Instruction Manual provided for this instrument. For more detailed information, refer to the Instruction Manual.



TEKTRONIX®

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485

OSCILLOSCOPE

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OPERATING INSTRUCTIONS

General

To effectively use the 485, the operation and capabilities of the instrument must be known. This section describes the operation of the front-, bottom, and rear-panel controls and connectors and gives first time and general operating information.

Operating Voltage and Environmental Cautions

WARNING

This instrument is designed for operation from a power source with its neutral at or near earth (ground) potential with a separate safety-earth conductor. It is not intended for operation from two phases of a multi-phase system, or across the legs of a single-phase, three-wire system.

The 485 can be operated from either a 115 V or 230 V nominal line voltage source, or a 220 V external DC source. The Line Voltage Selector switch on the rear panel converts

this instrument from one operating voltage to the other. See Instruction Manual for further information on DC operation.

CAUTION

This instrument may be damaged if operated with the Line Voltage Selector switch set to incorrect positions for the line voltage applied.

115 V	90-136 V
230 V	180-272 V

The 485 is designed to be used with a three-wire AC power system. If the three- to two-wire adapter is used to connect this instrument to a two-wire AC power system, be sure to connect the ground lead of the adapter to earth (ground). Failure to complete the ground system may allow the chassis of this instrument to be elevated above ground potential and pose a shock hazard.

Operating Temperature

The 485 can be operated where the ambient air temperature is between -15°C and $+55^{\circ}\text{C}$ ($+5^{\circ}\text{F}$ and 131°F). This instrument can be stored in ambient temperatures between -55°C and $+75^{\circ}\text{C}$ (-67°F and $+167^{\circ}\text{F}$). After storage at temperature beyond the operating limits, allow the chassis temperature to come within the operating limits before power is applied.

The 485 is cooled by air entering in through the air filter on the rear panel and exiting through the holes on the sides. Adequate clearance must be provided at these locations. Allow at least one inch clearance behind the air filter and on the sides.

A thermal cutout provides thermal protection and interrupts the power to the instrument if the internal temperature exceeds a safe operating level. Power is automatically restored when the temperature returns to a safe operating level. The air filter should be cleaned periodically to maintain adequate air flow into the instrument.

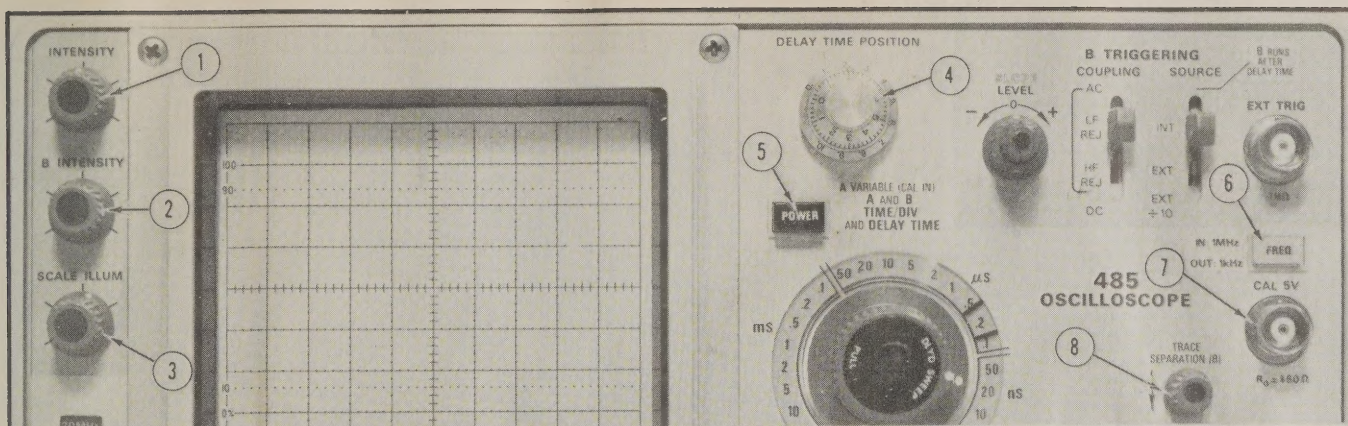
CONTROLS AND CONNECTORS

General

The major controls and connectors for operation of the 485 are located on the front panel of the instrument. Some auxiliary functions are provided on the bottom, and rear panel. To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of these controls and connectors. A brief description of each control and connector is given here. More detailed operating information is given in the Instruction Manual.

NOTE

Two types of crt graticules have been used in some Tektronix oscilloscopes. One graticule has 0% and 100% risetime reference points that are separated by 6 vertical graticule divisions. The other graticule has the 0% and 100% risetime reference points separated by 5 vertical divisions. In your manual, illustrations of the crt face or risetime measurement instructions may not correspond with the graticule markings on your oscilloscope.



1. INTENSITY Control

Controls brightness of writing beam.

2. B INTENSITY Control

Provides additional intensity control for the B SWEEP portion of a display.

3. SCALE ILLUM Control

Controls light level of graticule.

4. DELAY-TIME POSITION Control

Ten-turn calibrated control delays B sweep start (or B trigger arming) from 0 to 10 times the Time Base A TIME/DIV setting after the start of A sweep.

5. POWER Pushbutton

Turns instrument on or off.

6. FREQ Pushbutton

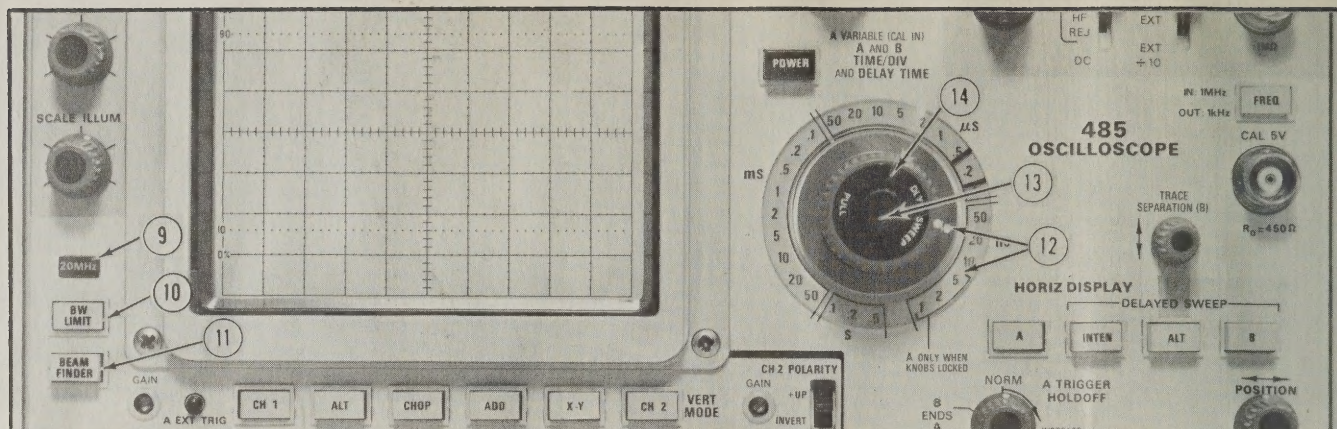
Selects one or two frequencies (1 kHz or 1 MHz) for the fast-rise calibrator signal.

7. CAL 5 V Connector

BNC connector for squarewave voltage calibrator output signal.

8. TRACE SEPARATION control

B (DLY'D) trace can be positioned 4 divisions from the A sweep.



9. 20 MHz Indicator

Lights when bandwidth of vertical amplifier is being limited.

10. BW LIMIT Pushbutton

Limits to approximately 20 MHz the bandwidth of the complete vertical amplifier system and of the INTERNAL TRIGGER signal.

11. BEAM FINDER Pushbutton

Compresses trace within graticule area independent of position control settings or amplitude of signal applied.

12. A AND B TIME/DIV AND DELAY TIME Switch

Selects calibrated A and B sweep rates from .5 s/div to 1 ns/div

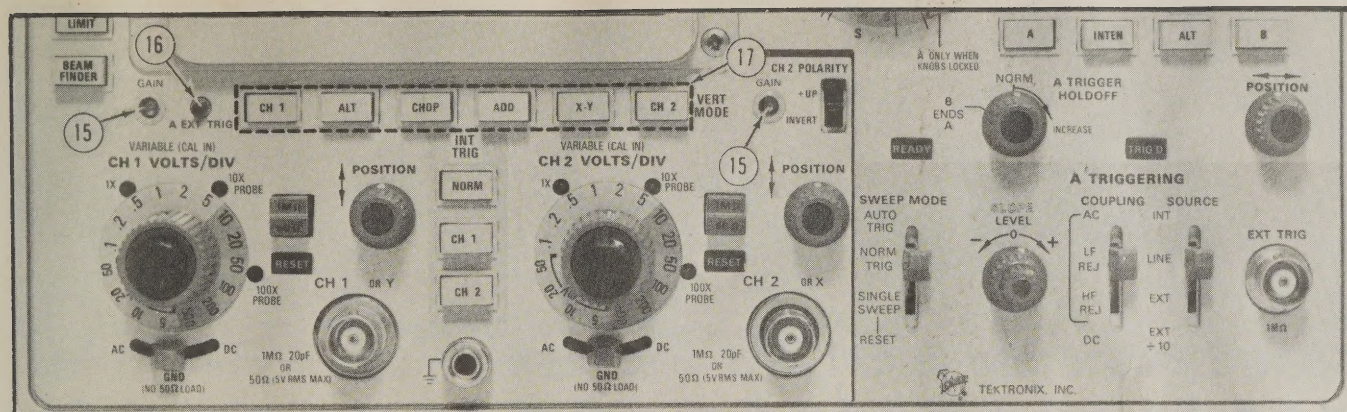
in 27 steps (1-2-5 sequence). Delay Time operation extends from .5 s/div to 10 ns/div.

13. A VARIABLE Control

Provides continuously variable A sweep rate to approximately 2.5 times the calibrated setting (uncalibrated sweep rate is extended to 1.25 s/div). Push away control provides calibrated rate in the CAL IN position.

14. DLY'D SWEEP PULL Knob

Provides for advancing the B (DLY'D) sweep rate ahead of the A (DELAYING) sweep rate. (When A rate is 1, 2, or 5 ns/div knobs are locked together).



15. GAIN Adjustment, CH 1 and CH 2

Screwdriver adjustment allows calibration of vertical deflection factor.

16. A EXT TRIG Pushbutton—(Momentary)

Overrides other vertical controls to display the external signal being used for A sweep triggering.

17. VERT MODE Pushbutton Selector (Blue Panel Background)

CH 1

Displays Channel 1 Only.

ALT

Dual-trace display by switching between channels at the end of A sweep.

CHOP

Dual-trace display by switching between channels every 0.5 μ s (1 MHz chopped display).

ADD

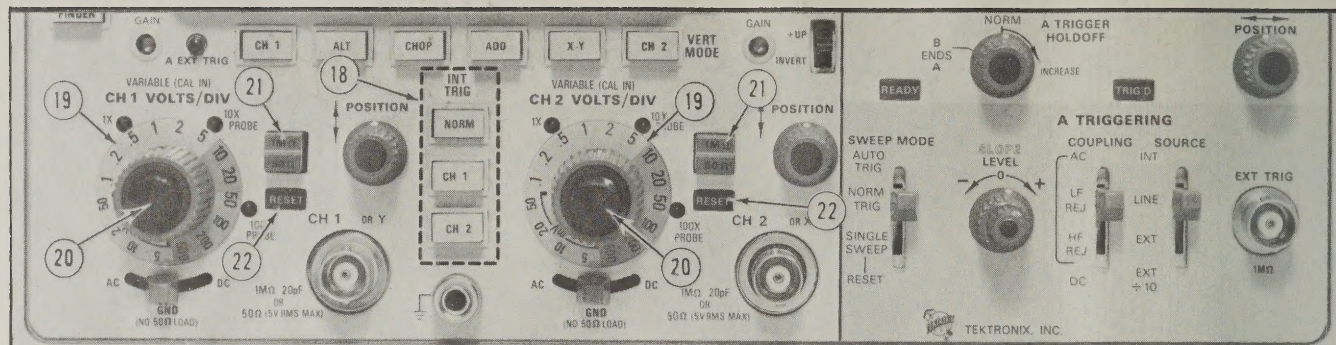
Algebraically adds CH 1 and CH 2 input signals.

X-Y

Permits X-Y operation. Displays CH 1 signal on the vertical (Y) axis and the CH 2 signal on the horizontal (X) axis, with a 4 MHz phase-compensated bandwidth.

CH 2

Displays CH 2 only.



18. INT TRIG Pushbutton Selector (Green Panel Background) NORM

The signal being displayed in the internal trigger source.

CH 1

Selects CH 1 as the internal trigger source.

CH 2

Selects CH 2 as the internal trigger source.

19. VOLTS/DIV Switch, CH 1 and CH 2

Selects 1X calibrated deflection factors from 5 mV/div to 5 V/div in ten steps (1-2-5 sequence). Attenuating probe tip deflection factors for X10 and X100, coded probes are automatically indicated by the three readout diodes at the circumference of this knob. All three diodes are off when the

channel is not selected for display by the VERT MODE selector, or when using probe IDENTify.

20. VARIABLE Volts/div Control, CH 1 and CH 2

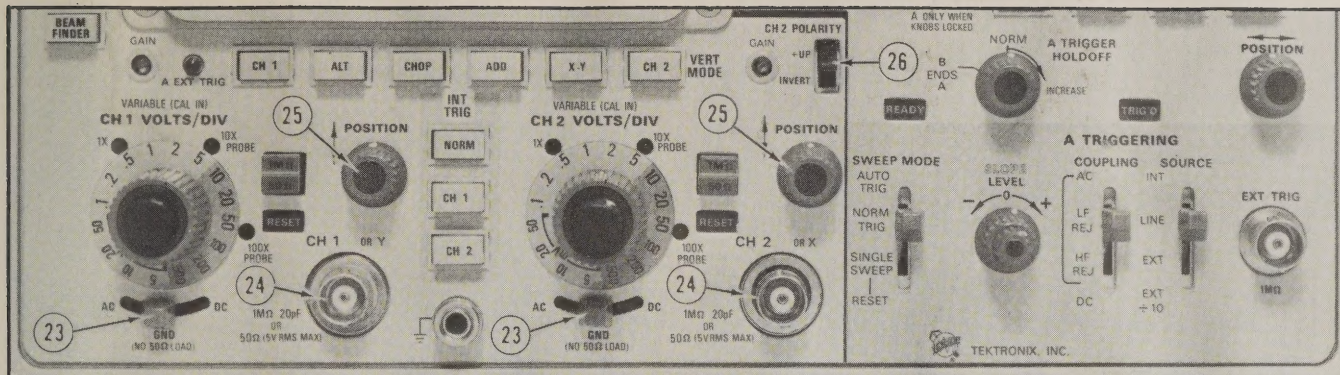
Provides continuously variable deflection factors between calibrated steps. Maximum deflection factor range is extended to 12.5 V/div. Push away control provides calibrated deflection factor in the CAL IN position.

21. 1 M Ω /50 Ω Switch, CH 1 and CH 2

Illuminated push-push selection for input impedance. Is also used to reset 50 Ω overload condition. 1 M Ω /50 Ω switch has to be pushed twice to return to 50 Ω input impedance.

22. RESET Indicator

When maximum input power is exceeded (5 V RMS) in the 50 Ω mode indicator is illuminated, and the 1 M Ω /50 Ω lamp is turned off.



23. Input Selector Switch, CH 1 and CH 2

AC

Capacitively couples input signal to vertical amplifier.

GND

Grounds the amplifier input and permits precharging the AC input coupling capacitor. 50 Ω termination is disconnected in the 50 Ω mode.

DC

Signal is directly coupled to the vertical amplifier.

24. Input CH 1 OR Y Connector and CH 2 OR X Connector

BNC connectors for applying external signals. Included are concentric coding rings for probes with scale factor and identify switching.

25. POSITION Controls, CH 1 and CH 2

Vertically position the display. In X-Y mode, CH 1 control positions in the Y axis and the CH 2 control positions in the X axis.

26. CH 2 POLARITY Switch

+UP and INVERT slide selector provides for inverting CH 2 display.

27. HORIZ DISPLAY Pushbutton Selector (Blue Panel Background)

(Inoperative in the X-Y VERT MODE and when timing knobs are locked in the 1, 2, and 5 ns/div position)

A

Displays A sweep

INTEN (A)

Displays A sweep intensified (after the delay time) for the duration of B sweep.

ALT

Alternately provides INTEN (A) and B (DLY'D) displays.

B (DLY'D)

Displays B (DLY'D) sweep.

28. Triggering COUPLING Switch, A TRIGGERING and B TRIGGERING

AC

Trigger signals are AC (capacitively) coupled to the trigger circuitry. Trigger signals below 16 Hz are attenuated.

LF REJ (AC Coupled)

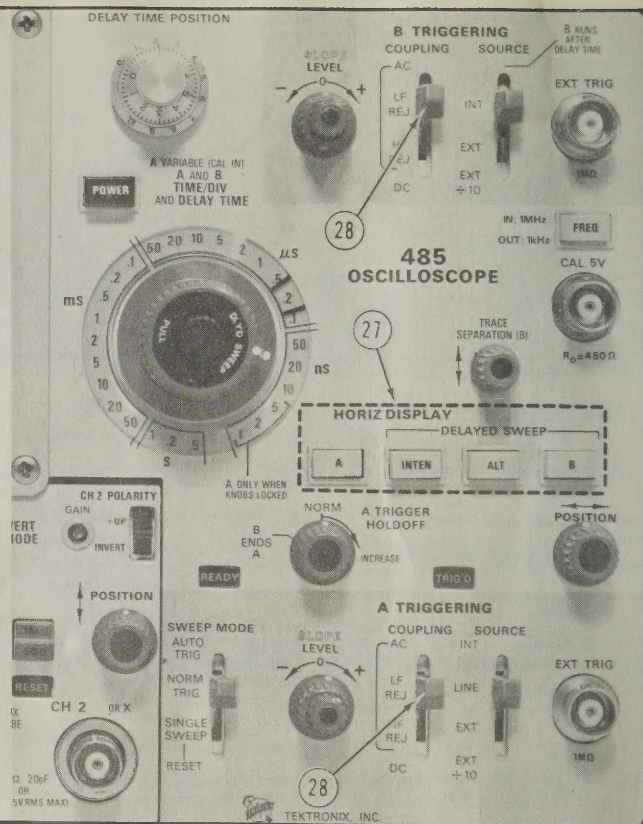
Attenuates triggering signal below 16 kHz.

HF REJ (AC Coupled)

Triggering signals below 16 Hz and above 50 kHz are attenuated.

DC

DC (direct) couples all trigger signals to the trigger circuitry.



29. Triggering SOURCE Switch, A TRIGGERING and B TRIGGERING (Green Panel Background)

INT

Uses the signal selected by the INT TRIG switch as the triggering signal.

LINE (A TRIGGERING Only)

Uses a portion of the line-frequency voltage as a trigger signal.

B RUNS AFTER DELAY TIME (B TRIGGERING Only)

B runs automatically after the time selected by A TIME/DIV and the calibrated DELAY TIME POSITION Control.

EXT

Permits triggering on signals applied to the EXT TRIG INPUT connector.

EXT 10

Attenuates external trigger signal by a factor of 10.

30. EXT TRIG Input Connector

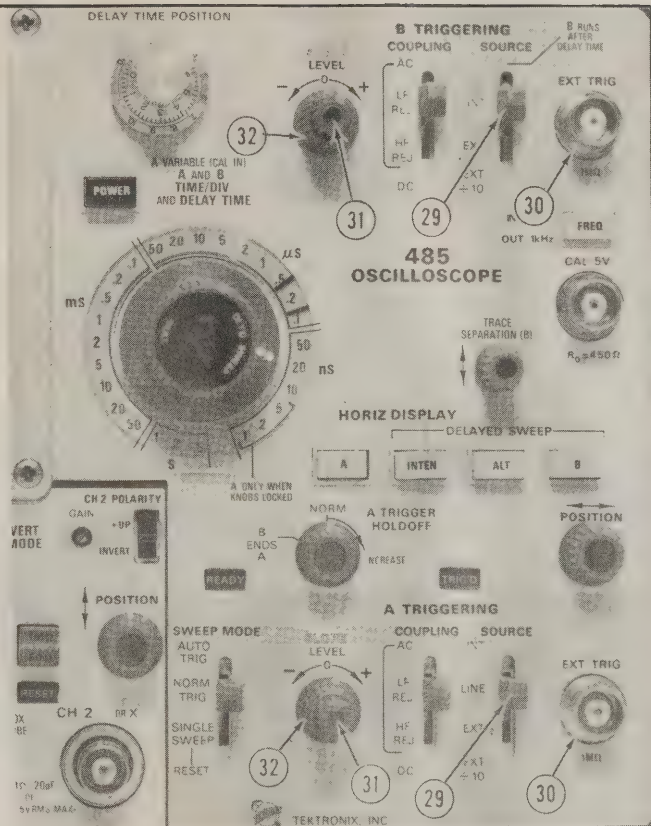
BNC connector providing input for external trigger signals.

31. SLOPE Switch, A TRIGGERING and B TRIGGERING

Permits triggering the sweep on the positive or negative going portion of the trigger signal.

32. LEVEL Control, A TRIGGERING and B TRIGGERING

Selects amplitude point on the triggering signal where sweep-triggering occurs.



33. TRIG'D Indicator

Lights when A sweep is triggered

34. SWEEP MODE Switch, A TRIGGERING AUTO TRIG

Permits normal triggering on waveforms with repetition rates of at least 20 Hz. Sweep free-runs in the absence of an adequate triggering signal.

NORM TRIG

Permits normal triggering. No CRT display in the absence of an adequate trigger signal.

SINGLE SWEEP

Displays one sweep only until reset.

RESET

A momentary-contact position of the SWEEP MODE switch that provides for re-arming the A sweep generator during the SINGLE SWEEP mode of operation.

35. READY Indicator

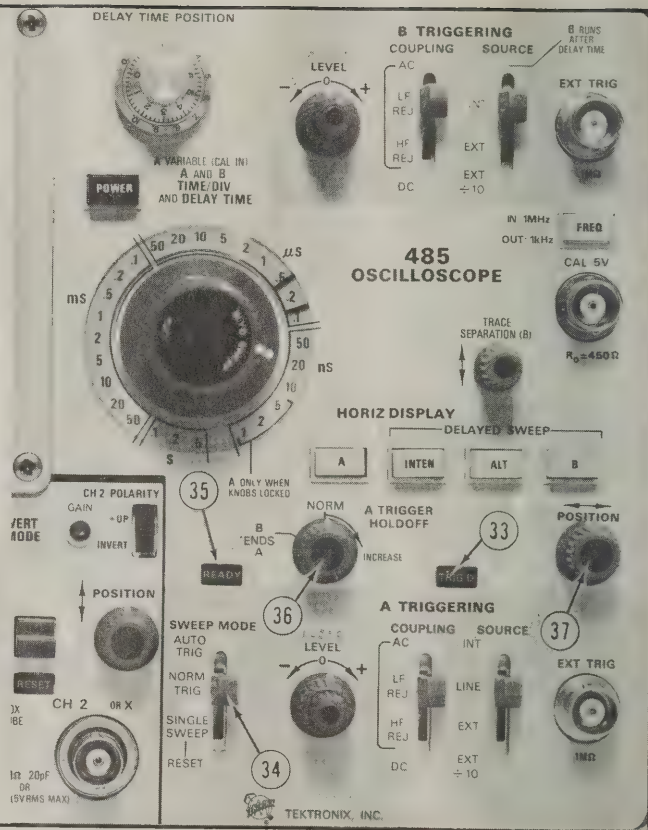
Is illuminated when A sweep is armed in the SINGLE SWEEP mode.

36. A TRIGGER HOLDOFF

Adjustable control of the time between sweep steps, permits a stable presentation of repetitive complex waveforms. The control covers at least the time of one full sweep for all but the two slowest sweeps.

37. POSITION (horizontal) Control

Horizontally positions trace. Inoperative in X-Y mode.



REAR PANEL

1. TRACE ROTATION Adjustment

Screw driver adjustment to align trace with horizontal graticule lines.

2. A +GATE

BNC connector providing a positive-going rectangular waveform coincident with A sweep.

3. B +GATE

BNC connector providing a positive-going rectangular waveform coincident with B sweep.

4. A SWEEP Connector

BNC connector provides a sample of A sawtooth generator signal.

5. Z AXIS INPUT Connector

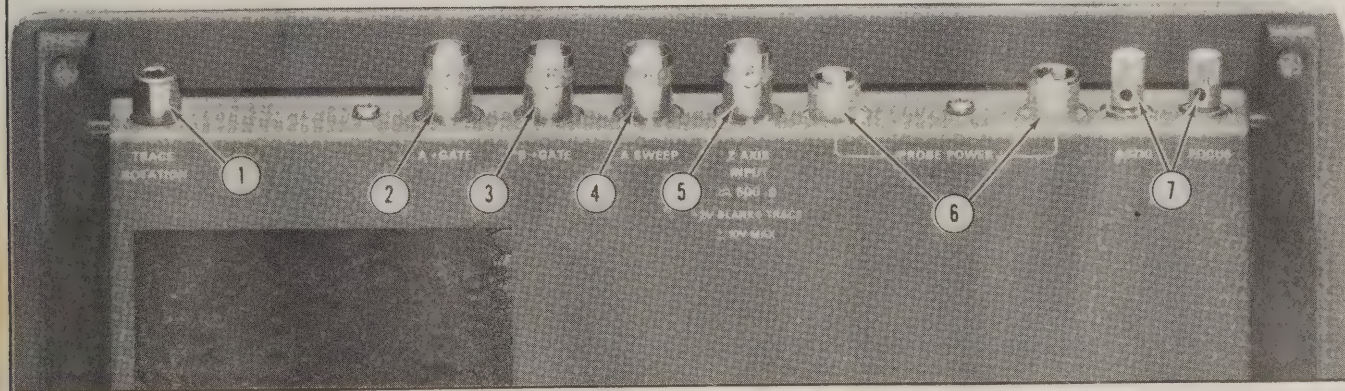
BNC input connector for intensity modulation of the CRT display.

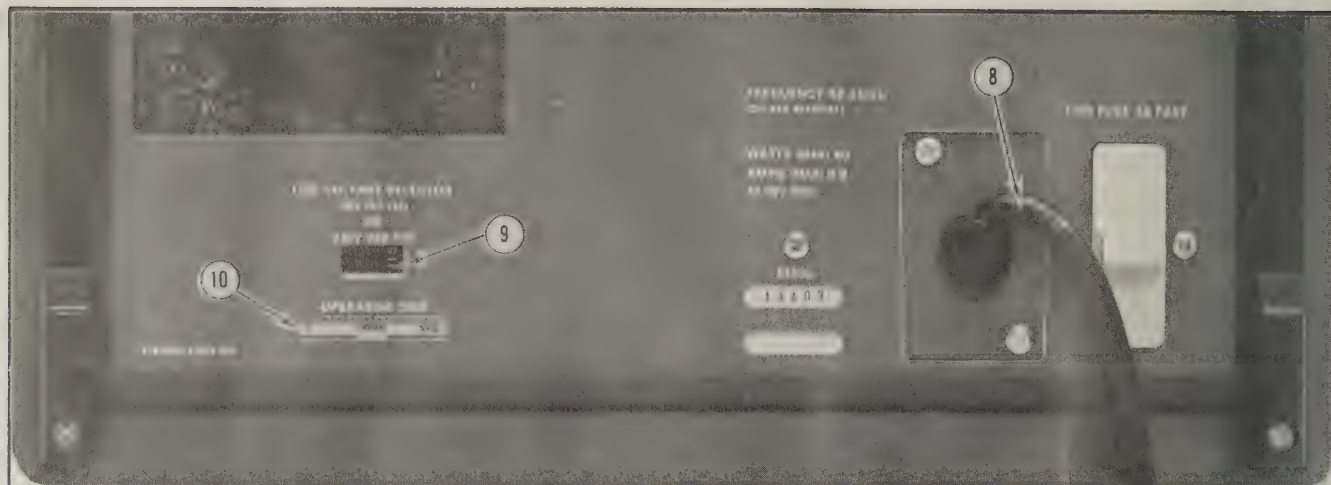
6. PROBE POWER

Power source for active probe systems.

7. FOCUS and ASTIG Adjustments

Adjustments used to obtain a well defined display. Requires infrequent readjustment.





8. LINE CORD

Power cord is a 3-wire, permanently attached cable. Approximately 7.5 feet in length.

9. LINE VOLTAGE SELECTOR

Recessed slide switch selects nominal operating line range. 115 V (90 V to 136 V) or 230 V (180 V to 272 V).

10. OPERATING TIME

Elapsed operating time indicator. 5000 hr. scale.

BOTTOM PANEL

1. 1 MΩ BAL, CH 1 and CH 2

Adjustment provides for DC balance of 1 MΩ Buffer amplifier.

USER'S CALIBRATION

General

To insure measurement accuracy, certain portions of the instrument calibration should be checked before making the measurement. The following is a procedure for checking the basic measurement capabilities of the 485. See the Calibration section of the Instruction Manual for more detailed calibration information.

Probe Compensation For Attenuating Probes Used With 1 M Ω Input

Variations in total input capacitance and resistance occur with different combinations of oscilloscopes and probes, attenuator probes are equipped with adjustments to compensate these differences. Probe compensation is accomplished as follows: Connect the probe to one of the oscilloscope's input connectors. Select 1 M Ω input impedance, obtain a display about five divisions in amplitude with one cycle of the calibrator 1 kHz signal displayed each two divisions. Check the waveform presentation for overshoot or rolloff, and readjust compensation for flat tops on the waveforms is necessary. See Fig. 1.

Vertical Gain Check

Connect probe to CAL 5 V to vertical input with the 18-inch BNC cable. Set the vertical input impedance to

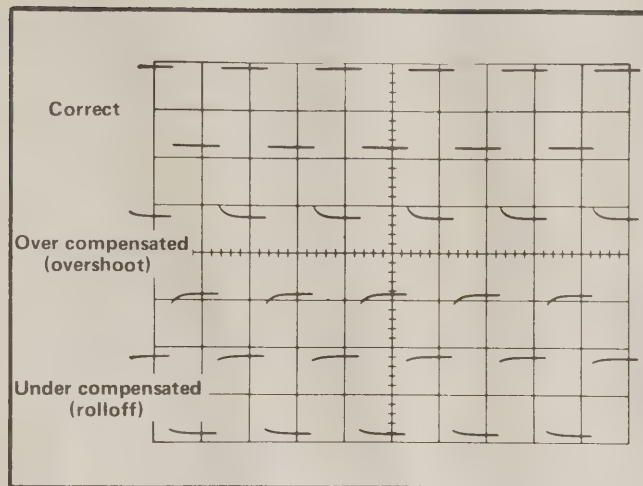


Fig. 1. Probe compensation.

50 Ω . Calibrator delivers 0.5 V to 50 Ω . Set the VOLTS/DIV to 0.1. Check for 5 div of vertical deflection and if necessary adjust the GAIN. Repeat this vertical gain procedure for other channel. 1 M Ω GAIN can then be checked at 1 V/DIV. The deflection factors for 10X and 100X probes can also be checked with the calibrator. Note: that the amplitude delivered to 500 Ω and 5000 Ω probes are 2.63 V and 4.59 V respectively.

To RESET push 1 M Ω /50 Ω to reactivate vertical to 1 M Ω input impedance. While in 1 M Ω impedance view the input signal to see the cause of the overload condition. To return to 50 Ω input impedance push 1 M Ω /50 Ω switch again.

Basic Timing

Set Calibrator frequency to 1 kHz. Trigger the display, set TIME/DIV to 1 ms and check for one cycle/div. Set Calibrator frequency to 1 MHz and TIME/DIV to 1 μ s. Check for one cycle/div. For a more complete timing check, refer to the calibration procedure given in the Instruction Manual.

APPLICATIONS

Peak-to-Peak Voltage Measurements

To make a peak-to-peak voltage measurement, use the following procedure:

1. Connect the signal to either INPUT connector.
2. Set the VERT MODE to display the channel used.
3. Set the VOLTS/DIV switch to display about five divisions of the waveform.

4. Set the A Triggering controls to obtain a stable display. Set the TIME/DIV switch to a position that displays several cycles of the waveform.

5. Turn the vertical POSITION control so the lower portion of the waveform coincides with one of the graticule lines below the center horizontal line, and the top of the waveform is on the viewing area. Move the display with the horizontal POSITION control, so one of the upper peaks lies near the center vertical line (see Fig. 2).

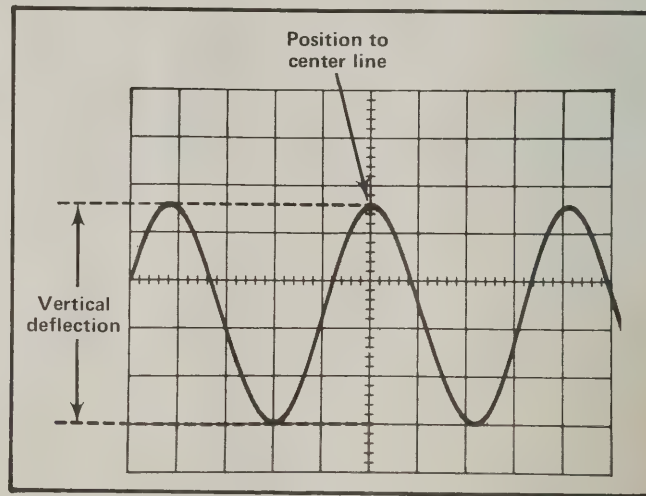


Fig. 2. Measuring peak-to-peak voltage of a waveform.

6. Measure the divisions of vertical deflection from peak to peak. Make sure the VARIABLE control is in the CAL position.

NOTE

This technique may also be used to make measurements between two points on the waveform rather than peak to peak.

7. Multiply the distance measured in step 7 by the VOLTS/DIV switch reading.

Example. Assume a peak-to-peak vertical deflection of 4.6 divisions (see Fig. 2) a VOLTS/DIV switch reading of .5.

Using the formula:

$$\begin{array}{ccccccc} \text{Volts} & & \text{vertical} & & \text{VOLTS/DIV} & & \text{probe} \\ \text{Peak to Peak} & = & \text{deflection} & \times & \text{setting} & \times & \text{attenuation} \\ & & \text{(divisions)} & & & & \text{factor} \end{array}$$

Substituting the given values:

$$\text{Volts Peak to Peak} = 4.6 \times .5 \text{ V}$$

The peak-to-peak voltage is 23 volts.

Instantaneous Voltage Measurements—DC

To measure the DC level at a given point on a waveform, use the following procedure:

1. Connect the signal to either INPUT connector.
2. Set the VERT MODE to display the channel used.
3. Set the VOLTS/DIV switch to display about five divisions of the waveform.
4. Set the Input Coupling switch to GND.
5. Set the SWEEP MODE switch to AUTO TRIG.
6. Position the trace to the bottom line of the graticule or other reference line. If the voltage to be measured is negative with respect to ground, position the trace to the top line of the graticule. Do not move the vertical POSITION control after this reference line has been established.

NOTE

To measure a voltage level with respect to a voltage other than ground, make the following changes in step 6: Set the Input Coupling switch to DC and apply the reference voltage to the INPUT connector. Then position the trace to the reference line.

7. Set the Input Coupling switch to DC. The ground reference line can be checked at any time by switching to the GND position.

8. Set the A Triggering controls to obtain a stable display. Set the TIME/DIV switch to a setting that displays several cycles of the signal.

9. Measure the distance in divisions between the reference line and the point on the waveform at which the DC level is to be measured. For example, in Fig. 3 the measurement is made between the reference line and point A.

10. Establish the polarity of the signal. If the waveform is above the reference line, the voltage is positive; below the line, negative (when the CH 2 POLARITY switch is +UP if using Channel 2).

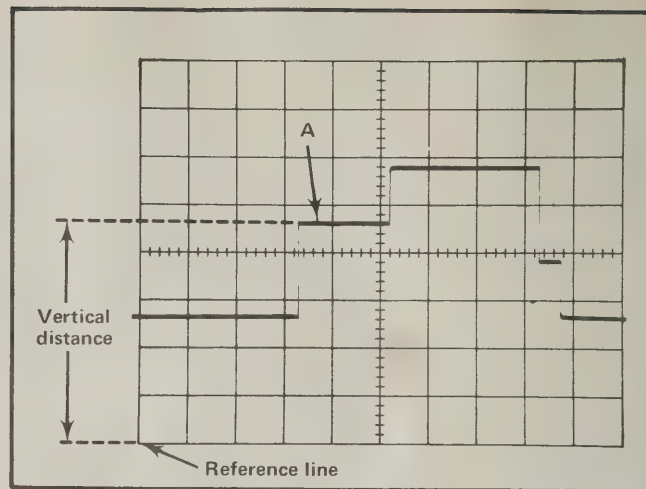


Fig. 3. Measuring instantaneous DC voltage with respect to a reference voltage.

11. Multiply the distance measured in step 9 by the VOLTS/DIV switch reading.

Example. Assume that the vertical distance measured is 4.6 divisions (see Fig. 3), the waveform is above the reference line, VOLTS/DIV switch reading of 2.

Using the formula:

Instantaneous =
Voltage

vertical
distance X polarity X VOLTS/DIV X probe
(divisions) setting attenuation
factor

Substituting the given values:

Instantaneous = 4.6 X 1 X 2 V
Voltage

The instantaneous voltage is 9.2 volts.

Comparison Measurements

In some applications it may be desirable to establish arbitrary units of measurement other than those indicated by the VOLTS/DIV switch or TIME/DIV switch. This is particularly useful when comparing unknown signals to a reference amplitude or repetition rate. One use for the comparison-measurement technique is to facilitate calibration of equipment (e.g., on an assembly-line test) where the desired amplitude or repetition rate does not produce an exact number of divisions of deflection. The adjustment will be easier and more accurate if arbitrary units of measurement are established so that correct adjustment is

indicated by an exact number of division of deflection. Arbitrary sweep rates can be useful for comparing harmonic signals to a fundamental frequency, or for comparing the repetition rate of the input and output pulses in a digital count-down circuit. The following procedure describes how to establish arbitrary units of measure for comparison measurements. Although the procedure for establishing vertical and horizontal arbitrary units of measurement is much the same, both processes are described in detail.

Vertical Deflection Factor. To establish an arbitrary vertical deflection factor based upon a specific reference amplitude, proceed as follows:

1. Connect the reference signal to the INPUT connector. Set the TIME/DIV switch to display several cycles of the signal.
2. Set the VOLTS/DIV switch and the VARIABLE control to produce a display an exact number of graticule divisions in amplitude. Do not change the VARIABLE control after obtaining the desired deflection. This display can be used as a reference for amplitude comparison measurements.
3. To establish an arbitrary vertical deflection factor so the amplitude of an unknown signal can be measured

accurately at any setting of the VOLTS/DIV switch, the amplitude of the reference signal must be known. If it is not known, it can be measured before the VARIABLE control is set in step 2.

4. Divide the amplitude of the reference signal (volts) by the product of the vertical deflection established in step 2 (divisions) and the setting of the VOLTS/DIV switch. This is the vertical conversion factor.

$$\text{Vertical Conversion Factor} = \frac{\text{reference signal amplitude (volts)}}{\text{vertical deflection (divisions)} \times \text{VOLTS/DIV switch setting}}$$

5. To measure the amplitude of an unknown signal, disconnect the reference signal and connect the unknown signal to the INPUT connector. Set the VOLTS/DIV switch to a setting that provides sufficient vertical deflection to make an accurate measurement. Do not readjust the VARIABLE control.

6. Measure the vertical deflection in divisions and calculate the amplitude of the unknown signal using the following formula.

$$\text{Signal Amplitude} = \text{VOLTS/DIV switch setting} \times \text{vertical conversion factor} \times \text{vertical deflection (divisions)}$$

Example. Assume a reference signal amplitude of 30 volts, a VOLTS/DIV switch setting of 5, and the VARIABLE control is adjusted to provide a vertical deflection of four divisions.

Substituting these values in the vertical conversion factor formula (step 4):

$$\text{Vertical Conversion Factor} = \frac{30 \text{ V}}{4 \times 5 \text{ V}} = 1.5$$

Then with a VOLTS/DIV switch setting of 1, the peak-to-peak amplitude of an unknown signal which produces a vertical deflection of five divisions can be determined by using the signal amplitude formula (step 6):

$$\text{Signal Amplitude} = 1 \text{ V} \times 1.5 \times 5 = 7.5 \text{ volts}$$

Sweep Rates. To establish an arbitrary horizontal sweep rate based upon a specific reference frequency, proceed as follows:

1. Connect the reference signal to the INPUT connector. Set the VOLTS/DIV switch for four or five divisions of vertical deflection.

2. Set the TIME/DIV switch and the A VARIABLE control so one cycle of the signal covers an exact number of horizontal divisions. Do not change the A VARIABLE control after obtaining the desired deflection. This display can be used as a reference for frequency comparison measurements.

3. To establish an arbitrary sweep rate so the repetition rate of an unknown signal can be measured accurately at any setting of the TIME/DIV switch, the repetition rate of the reference signal must be known. If it is not known, it can be measured before the A VARIABLE control is set in step 2.

4. Divide the repetition rate of the reference signal (seconds) by the product of the horizontal deflection established in step 2 (divisions) and the setting of the TIME/DIV switch. This is the horizontal conversion factor:

Horizontal
Conversion =
Factor

$$\frac{\text{reference signal repetition rate (seconds)}}{\text{horizontal deflection (divisions) X TIME/DIV switch setting}}$$

5. To measure the repetition rate of an unknown signal, disconnect the reference signal and connect the unknown signal to the INPUT connector. Set the TIME/DIV switch to a setting that provides sufficient horizontal deflection to make an accurate measurement. Do not readjust the A VARIABLE control.

6. Measure the horizontal deflection in divisions and calculate the repetition rate of the unknown signal using the following formula:

$$\text{Repetition Rate} = \frac{\text{TIME/DIV switch setting}}{\text{horizontal conversion factor} \times \text{horizontal deflection (divisions)}}$$

Example. Assume a reference signal frequency of 455 hertz (repetition rate 2.19 milliseconds), and a TIME/DIV

switch setting of .2 ms, with the A VARIABLE control adjusted to provide a horizontal deflection of eight divisions. Substituting these values in the horizontal conversion factor formula (step 4):

$$\begin{array}{l} \text{Horizontal} \\ \text{Conversion} \\ \text{Factor} \end{array} = \frac{2.19 \text{ milliseconds}}{.2 \times 8} = 1.37$$

Then, with a TIME/DIV switch setting of $50 \mu\text{s}$ the repetition rate of an unknown signal, which completes one cycle is seven horizontal divisions, can be determined by using the repetition rate formula (step 6):

$$\begin{array}{l} \text{Repetition} \\ \text{Rate} \end{array} = 50 \mu\text{s} \times 1.37 \times 7 = 480 \mu\text{s}$$

This answer can be converted to frequency by taking the reciprocal of the repetition rate (see applications on Determining Frequency).

Time-Duration Measurements

To measure time between two points on a waveform, use the following procedure:

1. Connect the signal to either INPUT connector.

2. Set the VERT MODE to display the channel used.

3. Set the VOLTS/DIV switch to display about five divisions of the waveform.

4. Set the A Triggering controls to obtain a stable display.

5. For best accuracy use the TIME/DIV setting that gives the greatest number of divisions between the time measurement points (see Fig. 4). Sweep Magnification (to obtain more displayed divisions) should be used when measuring portions of more complex waveforms.

6. Adjust the vertical POSITION control to move the points between which the time measurement is made to the center horizontal line.

7. Adjust the horizontal POSITION control to center the display within the center eight divisions of the graticule.

8. Measure the horizontal distance between the time measurement points. Be sure the A VARIABLE control is set to CAL.

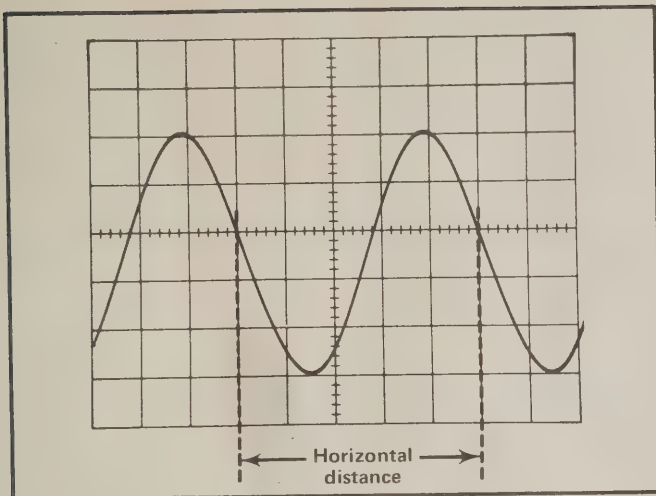


Fig. 4. Measuring the time duration between points on a waveform.

9. Multiply the distance measured in step 8 by the setting of the TIME/DIV switch.

Example. Assume that the distance between the time measurement points is five divisions (see Fig. 4) and the TIME/DIV switch is set to .1 ms.

Using the formula:

$$\text{Time Duration} = \frac{\text{horizontal distance}}{\text{(divisions)}} \times \text{TIME/DIV setting}$$

Substitute the given values:

$$\text{Time Duration} = 5 \times 0.1 \text{ ms}$$

The time duration is 0.5 millisecond.

Frequency Measurement

The time measurement technique can also be used to determine the frequency of a signal. The frequency of a periodically recurrent signal is the reciprocal of the time duration (period) of one cycle.

Use the following procedure:

1. Measure the time duration of one cycle of the waveform as described in the previous application.
2. Take the reciprocal of the time duration to determine the frequency.

Example. The frequency of the signal shown in Fig. 5 which has a time duration of 0.5 millisecond is:

$$\text{Frequency} = \frac{1}{\text{time duration}} = \frac{1}{0.5 \text{ ms}} = 2 \text{ kHz}$$

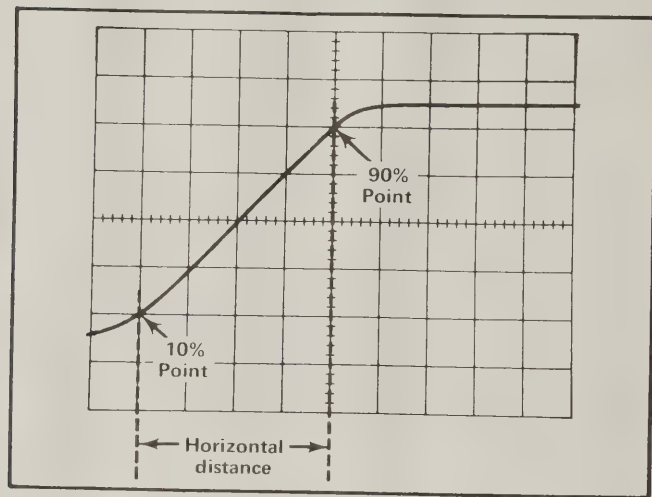


Fig. 5. Measuring risetime.

Risetime Measurements

Risetime measurements employ basically the same techniques as time-duration measurements. The main difference

is the points between which the measurement is made. The following procedure gives the basic method of measuring risetime between the 10% and 90% points of the waveform. Falltime can be measured in the same manner on the trailing edge of the waveform.

1. Connect the signal to either INPUT connector.
2. Set the VERT MODE to display the channel used.
3. Set the VOLTS/DIV switch and the VARIABLE control to produce a display an exact number of divisions in amplitude.
4. Center the display about the center horizontal line.
5. Set the TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the 10% and 90% points on the waveform.
6. Determine the 10% and 90% points on the rising portion of the waveform. The figures given in Table 1 are for the points 10% up from the start of the rising portion and 10% down from the top of the rising portion (90% point).

TABLE 1

Vertical display (divisions)	10% and 90% points	Divisions vertically between 10% and 90% point
4	0.4 division	3.2
5	0.5 division	4.0
6	0.6 division	4.8

NOTE

For a signal amplitude of 6 divisions, the 10% and 90% points are indicated on the graticule.

7. Adjust the horizontal POSITION control to move the 10% point of the waveform to the first graticule line. For example, with a five-division display as shown in Fig. 5, the 10% point is 0.5 division up from the start of the rising portion.

8. Measure the horizontal distance between the 10% and 90% points. Be sure^a the A VARIABLE control is set to CAL.

9. Multiply the distance measured in step 8 by the setting of the TIME/DIV switch.

Example. Assume that the horizontal distance between the 10% and 90% points is four divisions (see Fig. 5) and the TIME/DIV switch is set to $1\ \mu\text{s}$. Applying the time duration formula to risetime:

$$\begin{array}{l} \text{Risetime} \\ \text{Time Durations} \end{array} = \begin{array}{l} \text{horizontal} \\ \text{(divisions)} \\ \text{distance} \end{array} \times \begin{array}{l} \text{TIME/DIV} \\ \text{setting} \end{array}$$

Substituting the given values:

$$\text{Risetime} = 4 \times 1\ \mu\text{s}$$

The risetime is 4 microsecond.

Time-Difference Measurements

The calibrated sweep rate and dual-trace features of the 485 allow measurement of time difference between two separate events. To measure time difference, use the following procedure:

1. Set the Input Coupling switches to the desired coupling positions.
2. Set the VERT MODE to either CHOP or ALT. In general, CHOP is more suitable for low-frequency signals

and the ALT position is more suitable for high-frequency signals.

3. Set the INT TRIG to CH 1.

4. Connect the reference signal to INPUT CH 1 and the comparison signal to INPUT CH 2. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the INPUT connectors.

5. If the signals are of opposite polarity, switch CH 2 POLARITY to invert the Channel 2 display (signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation).

6. Set the VOLTS/DIV switches to produce four- or five-division displays.

7. Set the A LEVEL control for a stable display.

8. If possible, set the TIME/DIV switch for a sweep rate which shows three or more divisions between the two waveforms.

9. Adjust the vertical POSITION controls to center each waveform (or the points on the display between which the measurement is made) in relation to the center horizontal line.

10. Adjust the horizontal POSITION control so the Channel 1 (reference) waveform crosses the center horizontal line at a vertical graticule line.

11. Measure the horizontal difference between the Channel 1 waveform and the Channel 2 waveform (see Fig. 6).

12. Multiply the measured difference by the setting of the TIME/DIV switch.

Example. Assume that the TIME/DIV switch is set to $50 \mu\text{s}$, and the horizontal difference between waveforms is 4.5 divisions (see Fig. 6).

Using the formula:

$$\text{Time Delay} = \frac{\text{TIME/DIV}}{\text{setting}} \times \begin{matrix} \text{horizontal} \\ \text{difference} \\ \text{(divisions)} \end{matrix}$$

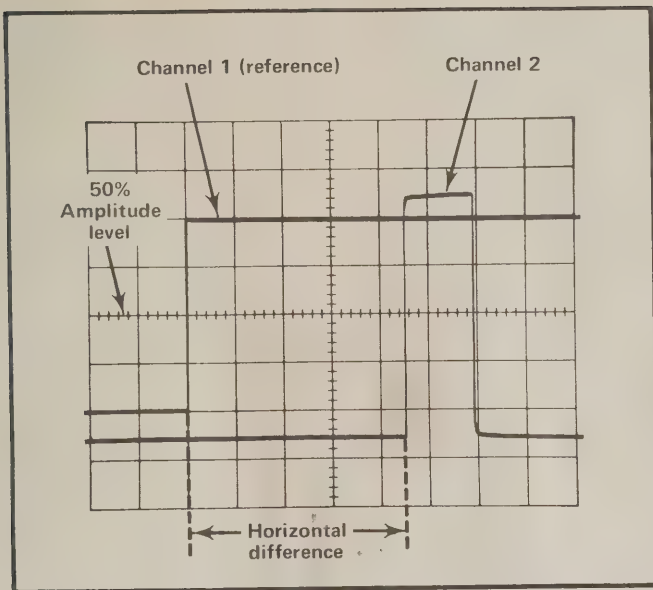


Fig. 6. Measuring time difference between two pulses.

Substituting the given values:

$$\text{Time Delay} = 50 \mu\text{s} \times 4.5$$

The time delay is 225 microseconds.

Delayed Sweep Time Measurement

The delayed sweep mode can be used to make accurate time measurements. The following measurement determines the time difference between two pulses displayed on the same trace. This application may also be used to measure time difference from two different sources (dual-trace) or to measure time duration of a single pulse.

1. Connect the signal to either INPUT connector. Set the VERT MODE to display the channel used.
2. Set the VOLTS/DIV switch to produce a display about four divisions in amplitude.
3. If possible, set the A TIME/DIV switch to a sweep rate which displays about eight divisions between the pulses.
4. Adjust the A Triggering controls for a stable display.
5. Set the HORIZ DISPLAY to INTEN and the B SWEEP SOURCE TRIGGERING switch to B RUNS AFTER DELAY TIME.

6. Set the B TIME/DIV switch to a setting 1/1000th of the A TIME/DIV sweep rate. This produces an intensified portion about 0.1 division in length.

7. Turn the DELAY-TIME POSITION dial to move the intensified portion to the first pulse.

8. Set the HORIZ DISPLAY to ALT.

9. Adjust TRACE SEPARATION for clear definition of both traces.

10. Adjust the DELAY-TIME POSITION dial to move the pulse (or the rising portion of the magnified sweep) to some vertical reference line. Note the setting of the DELAY-TIME MULTIPLIER dial.

11. Turn the DELAY-TIME POSITION dial clockwise until the second pulse is positioned to this same point.

12. Subtract the first dial setting from the second and multiply by the delay time shown by the A TIME/DIV switch. This is the time interval between the pulses.

Example. Assume the first dial setting is 1.31 and the second dial setting is 8.81 with the A TIME/DIV switch set to $0.2 \mu\text{s}$ (see Fig. 7).

Using the formula:

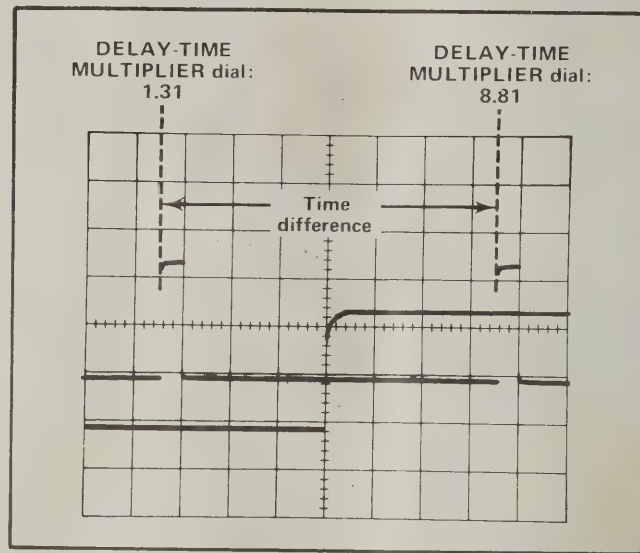


Fig. 7. Measuring time difference using delayed sweep.

Time Difference =
(delayed sweep)

$$\begin{array}{r} \text{second dial} \\ \text{setting} \end{array} - \begin{array}{r} \text{first dial} \\ \text{setting} \end{array} \times \begin{array}{r} \text{delay time} \\ \text{(A TIME/DIV} \\ \text{setting)} \end{array}$$

Substituting the given values:

$$\text{Time Difference} = (8.81 - 1.31) \times 0.2 \mu\text{s}.$$

The time difference is 1.5 microseconds.

Sweep Magnification

Wide range sweep magnification is provided by the delayed sweep of the 485. The DELAY-TIME POSITION control is used to select the portion of the A sweep to be magnified, and the DLY'D SWEEP control is pulled and advanced clockwise to select the amount of magnification. The HORIZ DISPLAY modes provide for viewing the portion to be magnified (INTEN), the magnified sweep (B), as well as simultaneous display of both (ALT). The B SOURCE of B RUNS AFTER delay would normally be used for magnifier operation, although for magnification above 100X or for signals having jitter, the other B SOURCE selection (triggerable) can be used.

1. Connect the signal to either INPUT connector. Set the VERT MODE to display the channel used.

2. Set the VOLTS/DIV switch to produce a display about four divisions in amplitude.

3. Set the A TIME/DIV switch to a sweep rate which displays the complete waveform.

4. Adjust the A Triggering controls for a stable display.

5. Set the HORIZ DISPLAY switch to ALT and the B TRIGGERING SOURCE switch to B RUNS AFTER DELAY TIME.

6. Position the start of the intensified portion with the DELAY-TIME POSITION dial to the part of the display to be magnified.

7. Set the B TIME/DIV switch to a setting which intensifies the full portion to be magnified. The start of the intensified trace remains as positioned above.

8. Time measurements can be made from the display in the conventional manner. Sweep rate is determined by the setting of the B TIME/DIV switch.

9. The apparent sweep magnification can be calculated by dividing the A TIME/DIV switch setting by the B TIME/DIV switch setting.

Example. The magnification of the display shown in Fig. 8 with an A TIME/DIV switch setting of .1 ms and a B TIME/DIV switch setting of $1\ \mu\text{s}$ is:

$$\text{Magnification (Delayed Sweep)} = \frac{\text{A TIME/DIV setting}}{\text{B TIME/DIV setting}}$$

Substituting the given values:

$$\text{Magnification} = \frac{.1\ \text{ms/Div}}{1\ \mu\text{s/Div}} = 100$$

The magnification is 100 times.

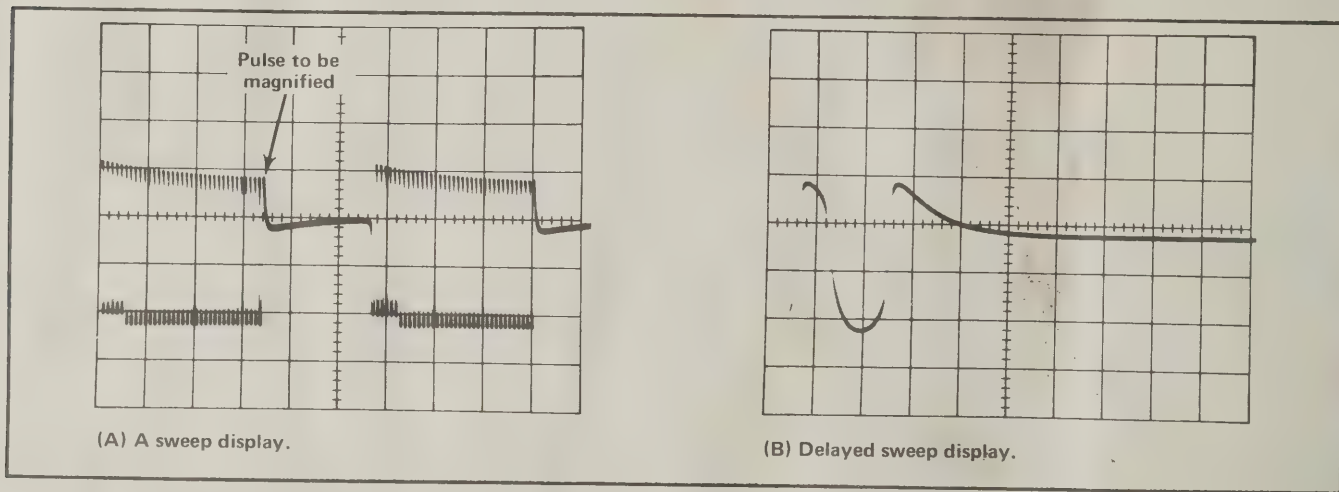


Fig. 8. Using delayed sweep for sweep magnification.

ALT operation displays the INTEN and B (DLY'D) sweeps simultaneously.

Triggered Delay Sweep Magnification. The delayed sweep magnification method just described may produce too much jitter at high apparent magnification ranges. The INT position of the B TRIGGER SOURCE switch provides a more stable display since the delayed display is triggered at the same point each time.

1. Set up the display as given in steps 1 through 7 described above.

2. Set the B SWEEP SOURCE switch to INT.

3. Adjust the B LEVEL control so the intensified portion on the trace is stable. (If an intensified portion cannot be obtained, see step 4.)

4. Inability to intensify the desired portion indicates that the signal does not meet the triggering requirements. If the condition cannot be remedied with the B Triggering controls or by increasing the display amplitude (lower VOLTS/DIV setting), trigger B sweep externally.

5. When the correct portion is intensified, set the HORIZ DISPLAY switch to ALT (DELAYED SWEEP). Slight readjustment of the B LEVEL control may be necessary for a stable display. Adjust TRACE SEPARATION for clear definition of both traces.

6. Measurement and magnification are as described above.

Pulse Jitter Measurements

In some applications it is necessary to measure the amount of time jitter on a pulse relative to either an earlier pulse in the same pulse train, or to some other triggering signal.

Use the following procedure:

1. Connect the signal to either INPUT connector. Set the VERT MODE to display the channel used.

2. Set the VOLTS/DIV switch to display about four divisions of the waveform.

3. Set the A TIME/DIV switch to a sweep rate which displays the complete waveform.

4. Set the A Triggering controls to obtain as stable a display as possible.

5. Set the HORIZ DISPLAY switch to ALT and the B TRIGGER SOURCE switch to B RUNS AFTER DELAY TIME.

6. Position the start of the intensified portion with the DELAY-TIME MULTIPLIER dial so the pulse to be measured is intensified.

7. Set the B TIME/DIV switch to a setting that intensifies the full portion of the pulse which shows jitter.

8. Pulse jitter is shown by horizontal movement of the pulse (take into account inherent jitter of Delayed Sweep). Measure the amount of horizontal movement. Be sure both VARIABLE controls are set to CAL.

9. Multiply the distance measured in step 8 by the B TIME/DIV switch setting to obtain pulse jitter in time.

Example. Assume that the horizontal movement is 0.5 divisions (see Fig. 9), and the B TIME/DIV switch setting is $0.5 \mu\text{s}$.

Using the formula:

$$\text{Pulse Jitter} = \frac{\text{horizontal jitter (divisions)}}{\text{B TIME/DIV setting}} \times \text{B TIME/DIV setting}$$

Substituting the given values:

$$\text{Pulse Jitter} = 0.5 \times 0.5 \mu\text{s}$$

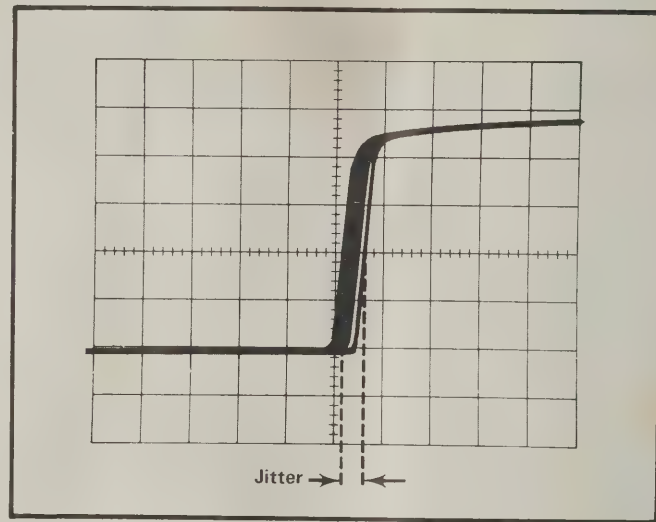


Fig. 9. Measuring pulse jitter.

The pulse jitter is 0.25 microsecond.

Delayed Trigger Generator

The B + GATE output signal can be used to trigger an external device at a selected delay time after the start of A Sweep. The delay time of the B + GATE output signal can be selected by the setting of the DELAY-TIME POSITION dial and A TIME/DIV switch.

A Sweep Triggered Internally. When A sweep is triggered internally to produce a normal display, the delayed trigger may be obtained as follows:

1. Obtain a trigger display in the normal manner.
2. Set the HORIZ DISPLAY switch to INTEN.
3. Select the amount of delay from the start of A Sweep with the DELAY-TIME POSITION dial. Delay time can be calculated in the normal manner.
4. Set the B TRIGGERING SOURCE switch to B RUNS AFTER DELAY TIME.

5. Connect the B + GATE signal to the external equipment.

6. The duration of the B + GATE signal is determined by the setting of the B TIME/DIV switch.

7. The external equipment will be triggered at the start of the intensified portion if it responds to positive-going triggers, or at the end of the intensified portion if it responds to negative-going triggers.

A Sweep Triggered Externally. This mode of operation can be used to produce a delayed trigger with or without a corresponding display. Connect the external trigger signal to the A EXT TRIG INPUT connector and set the A SOURCE switch to EXT. Follow the operation given above to obtain the delayed trigger.

Normal Trigger Generator

Ordinarily, the signal to be displayed also provides the trigger signal for the oscilloscope. In some instances, it may be desirable to reverse this situation and have the oscilloscope trigger the signal source. This can be done by connecting the A + GATE signal to the input of the signal

source. Set the A LEVEL control fully clockwise, A SWEEP MODE switch to AUTO TRIG and adjust the A TIME/DIV switch for the desired display. Since the signal source is triggered by a signal that has a fixed time relationship to the sweep, the output of the signal source can be displayed on the CRT as though the 485 were triggered in the normal manner.

Multi-Trace Phase Difference Measurements

Phase comparison between two signals of the same frequency can be made using the dual-trace feature of the 485. This method of phase difference measurement can be used up to the frequency limit of the vertical system. To make the comparison, use the following procedure:

1. Set the Input Coupling switches to the same position, depending on the type of coupling desired.

2. Set the VERT MODE to either CHOP or ALT. In general, CHOP is more suitable for low-frequency signals and the ALT position is more suitable for high-frequency signals.

3. Set the INT TRIGGER to CH 1.

4. Connect the reference signal to the INPUT CH 1 connector and the comparison signal to the INPUT CH 2 connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the INPUT connectors.

5. If the signals are of opposite polarity, set the CH 2 POLARITY switch to invert. (Signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation.)

6. Set the CH 1 and CH 2 VOLTS/DIV switches and the CH 1 and CH 2 VARIABLE controls so the displays are equal and about five divisions in amplitude.

7. Set the A Triggering controls to obtain a stable display.

8. Set the A TIME/DIV switch to a sweep rate which displays about one cycle of the waveform.

9. Move the waveforms to the center of the graticule with the CH 1 and CH 2 POSITION controls.

10. Turn the A VARIABLE control until one cycle of the reference signal (Channel 1) occupies exactly eight divisions between the first and ninth graticule lines (see Fig. 10). Each division of the graticule represents 45° of the cycle ($360^\circ \div 8 \text{ divisions} = 45^\circ/\text{division}$). The sweep rate can be stated in terms of degrees as $45^\circ/\text{division}$.

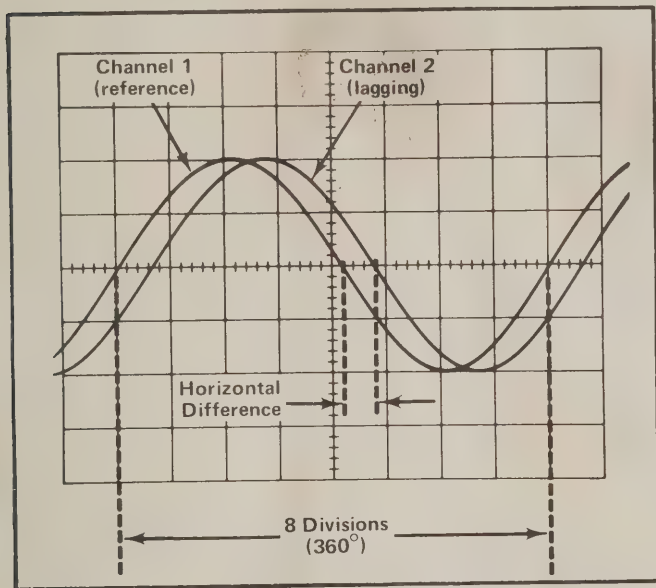


Fig. 10. Measuring phase difference.

11. Measure the horizontal difference between corresponding points on the waveforms.

12. Multiply the measured distance (in divisions) by $45^\circ/\text{division}$ (sweep rate) to obtain the exact amount of phase differences.

Example. Assume a horizontal difference of 0.6 division with a sweep rate of $45^\circ/\text{division}$ as shown in Fig. 10.

Using the formula:

$$\text{Phase Difference} = \frac{\text{horizontal difference}}{\text{(divisions)}} \times \text{sweep rate} \text{ (degrees/div)}$$

Substituting the given values:

$$\text{Phase Difference} = 0.6 \times 45^\circ$$

The phase difference is 27° .

X-Y Phase Measurement

The X-Y phase measurement method can be used to measure the phase difference between two signals of the

same frequency. This method provides an alternate method of measurement for signal frequencies up to four megahertz. However, above this frequency the inherent phase difference between the vertical and horizontal system makes accurate phase measurement difficult. In this mode, one of the sinewave signals provides horizontal deflection (X) while the other signal provides the vertical deflection (Y). The phase angle between the two signals can be determined from the lissajous pattern as follows:

1. Connect one of the sine-wave signals to the INPUT CH 1 or Y connector and the other signal to the INPUT CH 2 or X connector.

2. Set the VERT DISPLAY MODE to X-Y, and the INT TRIGGER to CH 1 ONLY.

3. Position the display to the center of the screen and adjust the CH 1 and CH 2 VOLTS/DIV switches to produce a display less than six divisions vertically (Y) and less than 10 divisions horizontally (X). The CH 2 VOLTS/DIV switch controls the horizontal deflection (X) and the CH 1 VOLTS/DIV switch controls the vertical deflection (Y).

4. Center the display in relation to the center graticule lines. Measure the distance A and B as shown in Fig. 11. Distance A is the horizontal measurement between the two points where the trace crosses the center horizontal line. Distance B is the maximum horizontal width of the display.

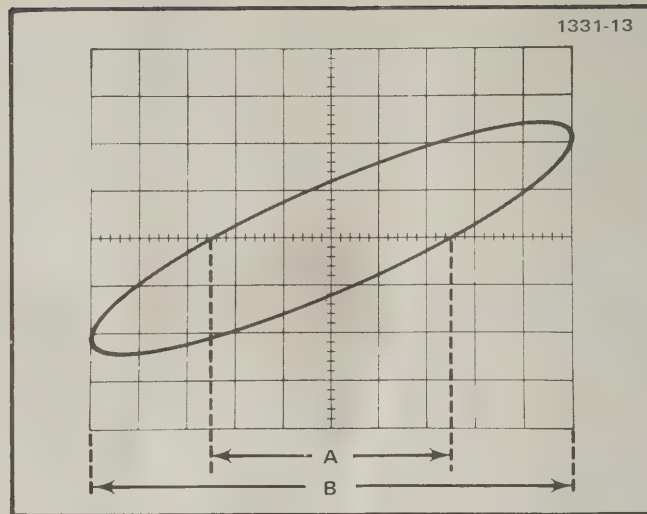


Fig. 11. Phase-difference measurement from an X-Y display.

5. Divide A by B to obtain the sine of the phase angle (Φ) between the two signals. The angle can then be obtained from a trigonometric table.

6. If the display appears as a diagonal straight line, the two signals are either in phase (tilted upper right to lower left) or 180° out of phase (tilted upper left to lower right). If the display is a circle, the signals are 90° out of phase.

Example. To measure the phase of the display shown in Fig. 1.1 where A is 5 divisions and B is 10 divisions, use the formula:

$$\text{Sine } \Phi = \frac{A}{B}$$

Substituting the given values:

$$\text{Sine } \Phi = \frac{5}{10} = 0.5$$

From the trigonometric tables:

$$\Phi = 30^\circ$$

Common-Mode Rejection

The ADD feature of the 485 can be used to display signals which contain undesirable components. These undesirable components can be eliminated through common-mode rejection.

NOTE

The following general precautions should be observed when using the ADD mode.

a. Do not exceed the input voltage rating of the 485.

b. Do not apply signals that exceed an equivalent of about eight times the VOLTS/DIV switch setting. For example, with a VOLTS/DIV switch setting of 0.5, the voltage applied to that channel should not exceed about four volts. Larger voltages may distort the display.

c. Use CH 1 and CH 2 POSITION control settings which most nearly position the signal of each channel to mid-screen when viewed in either the CH 1 or CH 2 positions of the VERT MODE switch. This insures the greatest dynamic range for ADD mode operation.

d. For similar response from each channel, set the CH 1 and CH 2 Input Coupling switches to the same position.

1. Connect the signal containing both the desired and undesired information to the INPUT CH 1 connector.
2. Connect a signal similar to the unwanted portion of the Channel 1 signal to the INPUT CH 2 connector.
3. Set both Input Coupling switches to DC (AC if DC component of input signal is too large).
4. Set the VERT MODE to ALT. Set the VOLTS/DIV switches so the signals are about equal in amplitude.

5. Set the INT TRIGGER to NORM.

6. Set the VERT MODE to ADD. Set CH 2 POLARITY to INVERT so the common-mode signals are of opposite polarity.

7. Adjust the CH 2 VOLTS/DIV switch and CH 2 VARIABLE control for maximum cancellation of the common-mode signal.

8. The signal which remains should be only the desired portion of the Channel 1 signal. The undesired signal is cancelled out.

Example. An example of this mode of operation is shown in Fig. 12. The signal applied to Channel 1 contains unwanted line-frequency components (see Fig. 12A). A corresponding line-frequency signal is connected to Channel 2 (see Fig. 12B). Fig. 12C shows the desired portion of the signal as displayed when common-mode rejection is used.

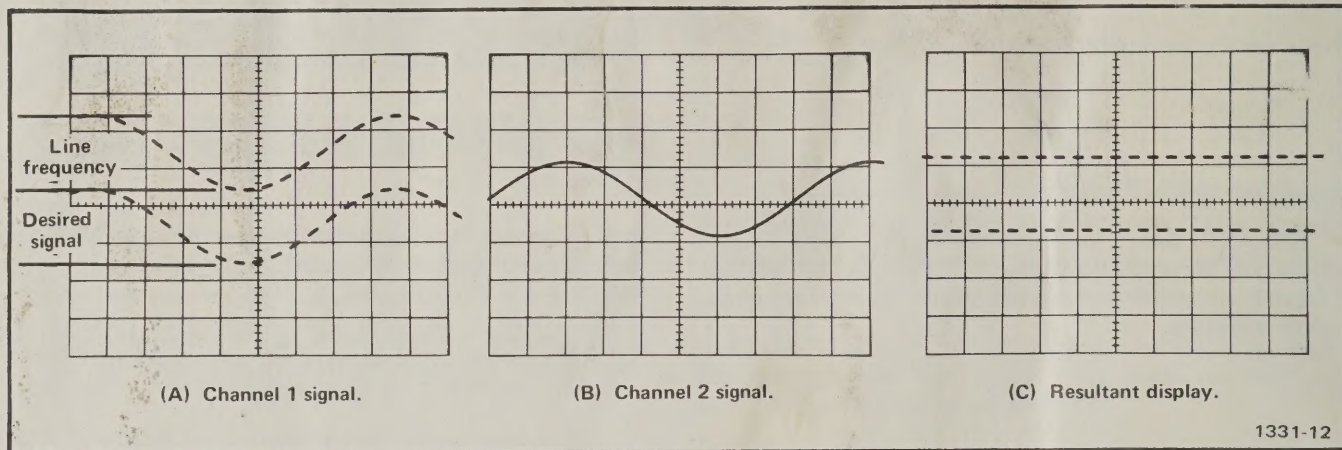


Fig. 12. Using the ADD feature for common-mode rejection. (A) Channel 1 signal contains desired information along with line-frequency component. (B) Channel 2 signal contains line-frequency only, (C) CRT display using common-mode rejection.

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